Non-contemporaneity in the Marulan Batholith

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The Lockyersleigh Adamellite and Chapmans Creek Granodiorite crop out near Brayton New South Wales and form part of the composite Marulan Batholith. A Rb-Sr whole-rock isochron for these two plutons indicates an emplacement age of 326 ± 6Ma with an initial $^{87}Sr/^{86}Sr$ ratio of 0.7049. These isotopic data are very similar to published data for the Carboniferous Bathurst Batholith (mean age of 310Ma) but differ significantly from published data which indicate a Devonian age (approximately 400Ma) for other plutons in the Marulan Batholith. The low initial $^{87}Sr/^{86}Sr$ ratio implies that the two plutons at Brayton were derived from an isotopically relatively unevolved I-type source.

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INTRODUCTION

The Marulan Batholith and comagmatic igneous rocks of the Bindook Volcanic Complex crop out in the eastern part of the Lachlan Fold Belt of New South Wales (Fig. 1) and comprise a series of plutonic rocks and associated lavas and pyroclastics which have an outcrop area of approximately 1350km^2. Naylor (1939) considered that the batholith was intruded during Devonian time and isotopic dating by Carr *et al.* (1980) and Flood *et al.* (1982) has confirmed this age of emplacement. Two plutons of the batholith which occur near Brayton (Fig. 1) were assigned a Devonian age by Naylor (1939) whereas Brunker and Offenberg (1968) regarded these intrusions as Carboniferous. Isotopic data for the Brayton plutons have not been published previously and the present investigation, which is part of a larger project on the Marulan Batholith and Bindook Volcanic Complex, was undertaken to resolve the age of these intrusions by using Rb-Sr isotopic techniques.

MARULAN BATHOLITH

Plutons of the composite Marulan Batholith form approximately 36% of the outcrop area of the southern half of the Bindook Volcanic Complex and show a compositional range from tonalite and granodiorite through adamellite to granite and alkali feldspar granite. Most plutons are relatively small and are elongate meridionally.

AGE CONSTRAINTS

The youngest stratified units with age-diagnostic fossil assemblages which are intruded by plutons of the Marulan Batholith are the Bungonia Limestone and the overlying Tangerang Formation. The Bungonia Limestone contains Ludlovian (Late Silurian) fossils in the lower part and a Lochkovian (earliest Devonian) fauna near the top of the formation (Jones *et al.*, 1981), and Lochkovian faunas have been recorded from the basal part of the Tangerang Formation (Jones *et al.*, 1984; Jones *et al.*, 1986; Mawson, 1975). The oldest rocks which unconformably overlie plutons of the batholith are Late Devonian marine and terrestrial strata which crop out to the west of Bungonia (Naylor, 1939). These stratigraphic data indicate that the batholith in general is younger than earliest Devonian but older than Late Devonian.

Fig. 1. Simplified geological map showing location of the Bathurst Batholith and the Marulan Batholith together with the comagmatic Bindook Volcanic Complex. Sample locations and detailed geology of the Brayton district are shown in the inset.

Evernden and Richards (1962) obtained a Carboniferous age (313Ma; as recalculated using the constants of Steiger and Jager, 1977) for a biotite separate from a pluton of the batholith and commented on the discordance between the stratigraphic age and the isotopic data. Vallance (*in* Packham, 1969: 198) and O'Reilly (1972) were also aware of the anomaly.

K-Ar dates on biotite separates from three different plutons of the southern part of the batholith indicate a mean age of emplacement of 398Ma (Carr *et al.*, 1980). The average Rb-Sr biotite age for the Marulan Batholith is 400Ma (Flood *et al.*, 1982) and both the K-Ar and Rb-Sr biotite data are consistent with a 12-point whole-rock Rb-Sr isochron age of 419 ± 33 (Flood *et al.*, 1982).

BRAYTON PLUTONS

The oldest rocks in the Brayton district (Fig. 1) are a Late Ordovician sequence of isoclinally folded slate, quartzite and phyllite which is unconformably overlain by sedimentary strata and basic volcanic rocks of Silurian age (MacRae, 1978). These basic volcanic rocks are overlain by, or faulted against, dacite and tuff of the Bindook Volcanic Complex which Carr *et al.* (1980) and Jones *et al.* (1984) have equated with the Early Devonian Tangerang Formation of the Bungonia region.

The Ordovician to Early Devonian sequence at Brayton was intruded by two plutons of the Marulan Batholith, the Lockyersleigh Adamellite and Chapmans Creek Granodiorite. O'Reilly (1972) referred to the latter intrusion as the Towrang granodiorite but as the name Towrang Beds has priority (Brunker and Offenberg, 1968) the intrusion is named herein as the Chapmans Creek Granodiorite. Tertiary basalts, dolerites and sedimentary strata post-date the adamellite and granodiorite (O'Reilly, 1972).

Stratigraphic criteria impose only broad limits on the age of the Lockyersleigh Adamellite and Chapmans Creek Granodiorite. The intrusive relationship with the rocks of the Bindook Volcanic Complex indicates a post-Early Devonian emplacement whereas the non-metamorphosed Tertiary rocks indicate intrusion prior to the Tertiary. The petrography of the various rocks and the contact metamorphic effects associated with the intrusion of the adamellite and granodiorite have been described in detail by O'Reilly (1972). Both plutons are composed of holocrystalline, granular rocks containing perthitic alkali feldspar, plagioclase, quartz, biotite and accessory sphene, iron-titanium oxides, zircon and apatite. Hornblende occurs in the adamellite but is absent from the granodiorite. Aplite veins composed of alkali feldspar and quartz occur in both plutons.

TABLE 1

Rb-Sr data for Lockyersleigh Adamellite (LA) and Chapmans Creek Granodiorite (CCG)

SAMPLE	PLUTON	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$ ($\pm 2\sigma$)
1120	LA	167	534	0.905	.70899 ± 19
1121	LA	50	1029	0.141	.70553 ± 11
1122	CCG	140	671	0.606	.70802 ± 05
1170	CCG	140	164	2.471	.71638 ± 05
1188	LA	152	615	0.715	.70827 ± 05

Rb-Sr data have been determined for five whole-rock samples from the two plutons at Brayton and the results are presented in Table 1 and Fig. 2. Regression of the data for all five samples yields an age of 328 ± 6Ma (Table 2) but the high value for the mean

square of the weighted deviates (MSWD = 15.00) indicates that the scatter is in excess of that attributable to analytical uncertainty alone. Exclusion of sample 1122 from the regression reduces the MSWD to an acceptably low value of 2.48 (Table 2) but does not make a significant difference to the date (326 ± 6Ma). The resultant initial $^{87}Sr/^{86}Sr$ ratio is 0.7049.

TABLE 2

Regression analyses for Lockyersleigh Adamellite and Chapmans Creek Granodiorite

SAMPLES FOR MODEL 1 ISOCHRON	INITIAL $^{87}Sr/^{86}Sr$ (± 2σ)	AGE (Ma) (± 2σ)	MSWD
1120, 1121, 1122, 1170, 1188	.7049 ± 1	328 ± 6	15.00
1120, 1121, 1170, 1188	.7049 ± 1	326 ± 6	2.48

Age calculated using $\lambda = 1.42 \times 10^{-11}\ yr^{-1}$

DISCUSSION

The Rb-Sr isochron for the four samples indicates that the two plutons at Brayton were emplaced during the Carboniferous and are not contemporaneous with other plutons from the Marulan Batholith which have been dated by Carr *et al.* (1980) and Flood *et al.* (1982). The age of the Lockyersleigh Adamellite and Chapmans Creek Granodiorite does imply a temporal correlation with the Bathurst Batholith which crops out

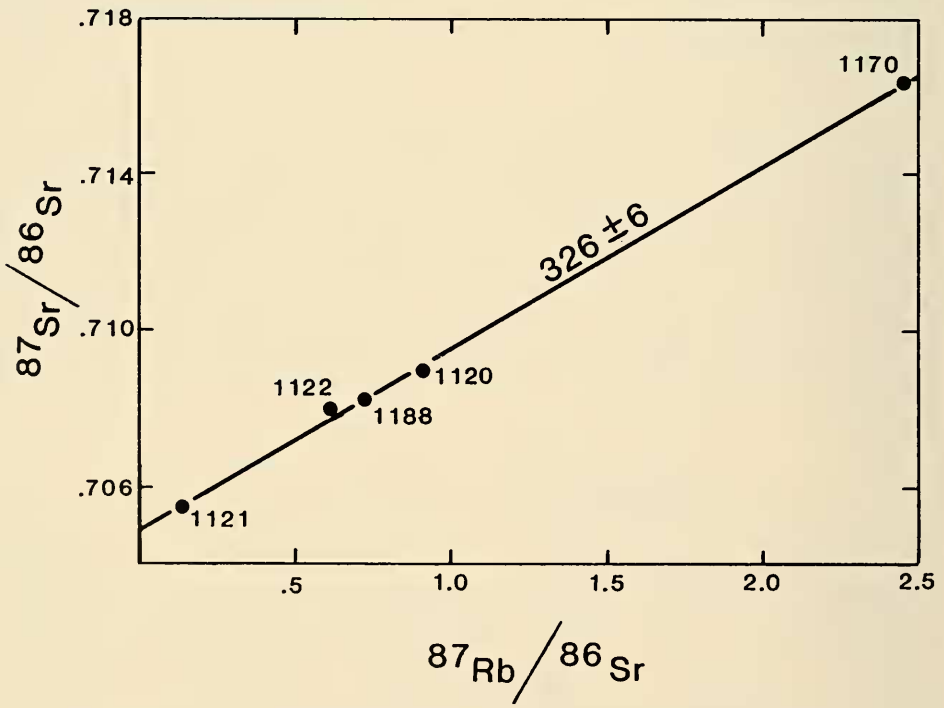

Fig. 2. Isochron diagram for the Lockyersleigh Adamellite and Chapmans Creek Granodiorite.

over an area of at least 1600km^2 in the Bathurst region of New South Wales (Fig. 1) and has a mean age of emplacement of 310Ma (Facer, 1979). In addition, the initial

$^{87}Sr/^{86}Sr$ ratio of 0.7049 for the Brayton plutons is indistinguishable from the initial ratio of 0.7047 for the Bathurst Batholith (Flood *et al.*, 1982) but is significantly different from the initial ratio of 0.7061 for the Marulan Batholith and the Bindook Volcanic Complex (Flood *et al.*, 1982).

The K-Ar biotite age of 313Ma (recalculated) obtained by Evernden and Richards (1962) for a pluton of the Marulan Batholith is similar to the mean age of the Bathurst Batholith (310Ma) and the plutons at Brayton (326Ma). This similarity in age may be fortuitous due to the loss of radiogenic argon or it may indicate the presence of another Carboniferous pluton in the Marulan Batholith.

Mineralogical, chemical and isotopic properties of the granitic rocks of the Lachlan Fold Belt generally permit subdivision into one of two groups (White and Chappell, 1983) which reflect derivation by partial melting of igneous rocks ('I-type granitoids') or sedimentary rocks ('S-type granitoids'). The low initial $^{87}Sr/^{86}Sr$ ratio (0.7049) obtained in the present study indicates that the plutons at Brayton were generated from an isotopically relatively unevolved source and the ratio is consistent with the I-type mineralogical and chemical characteristics which White and Chappell (1983) have documented for the Marulan and Bathurst Batholiths.

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